Historic, archived document
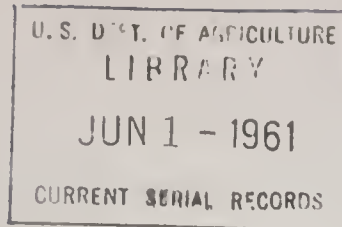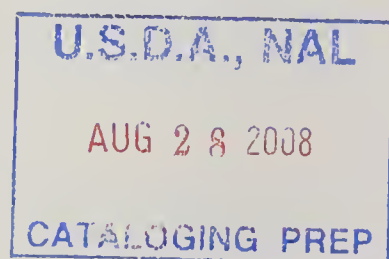
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COMPUTING AVERAGE LOG VALUES FOR TIMBER APPRAISALS USING IBM 650 OR UNIVAC SOLID STATE 80 COMPUTERS

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A necessary part of most timber appraisals is to determine the relationship between average value per 1,000 board feet and scaling diameter for logs of known log grades. In the past, this average value has been determined by first computing the values per 1,000 board feet for individual logs of known diameter and log grade and then relating these values, usually graphically, to any log diameter. The plotted data ordinarily vary a good deal. Therefore, to prepare tables of average log value, it is necessary to eliminate the variation by fitting smooth curves to the data and determining values directly from the curves.

This procedure has several disadvantages which have been discussed by Johnson. [1] To overcome these disadvantages, he has suggested that separate regressions be computed relating individual log volume and individual log value to log scaling diameter. The volume and value for given diameters are computed from the regressions, and the average value per 1,000 board feet for each diameter is computed by dividing the value by the volume.

Computation of the regressions and the subsequent calculations are readily adaptable to electronic computers. Newport and Leach [2] have reported a machine program which computes individual log values for logs with known lumber recovery volumes and diameters.

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[1] Johnson, Floyd A., "Evolution of Analysis Procedures for Lumber Recovery Studies in the Pacific Northwest," U. S. Forest Serv. Pacific Northwest Forest and Range Expt. Sta. Statistical Tech. Report 2-60, April, 1960.

[2] Newport, C. A. and Joe Leach. A method for the application of change in grade factors to individual logs. U. S. Forest Serv. Pacific Southwest Forest and Range Expt. Sta. Tech. Paper 41, 9 pp., 1 p. addendum, 1959. The IBM 650 program presented in Tech. Paper 41 has also been adapted for the Univac Solid State 80 computer. Either program can be obtained by writing to the Director, Pacific Southwest Forest and Range Expt. Sta., P. O. Box 245, Berkeley 1, California.

The Division of Timber Management in Region 5 of the Forest Service, which has been using the Newport-Leach program for analyzing mill study data, wanted a program of the type suggested by Johnson to develop average log values. It was assumed that a second degree polynomial of the type:

$$Y = a + bX + cX^2$$

where Y = value or volume and X = log diameter, best describes the relationship between log diameter and log volume or log value. [3] This report presents a computer program which does these calculations. It can be used independent of, or in conjunction with, the Newport-Leach 650 program.

WHAT THE PROGRAM DOES

The Newport-Leach program combined with this new program will do the following calculations (fig. 1).

1. Convert rough green lumber tally of individual logs by lumber grades to surfaced dry lumber tally by lumber grades. (Newport-Leach Program)

2. Compute total surface dry lumber volume for individual logs by summing surfaced dry volume in all lumber grades. (Newport-Leach Program)

3. Compute total value of individual logs by multiplying the surfaced dry volume in each lumber grade by the lumber grade price and summing for all lumber grades. (Newport-Leach Program)

4. Compute a regression of individual log volume on log diameter. (Frazier-Carney Program)

5. Compute tables of average log volume by diameter classes for each log grade of specified log grade systems. (Frazier-Carney Program)

6. Compute a regression of individual log value on log diameter. (Frazier-Carney Program)

7. Compute tables of average log value by diameter classes for each log grade of specified log grade systems. (Frazier-Carney Program)

8. Compute average value per 1,000 board feet by diameter class for each log grade of specified log grade systems. (Frazier-Carney Program)

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[3] This program should be used only when it can be assumed that this relationship is valid for the data being used.

The program computes regressions by the method of least squares of the general type:

$$Y_{ijk} = a_{ijk} + b_{ijk} X + c_{ijk} X^2$$

$$i = 1 = \text{Individual log volume}$$
$$= 2 = \text{Individual log value}$$
$$j = 1,2,3\ldots\ldots6 = \text{Log grading system}$$
$$k = 1,2,3\ldots\ldots6 = \text{Log grade}$$
$$X = \text{Log scaling diameter}$$

The program will compute (J times K) = 36 regressions of this type.

Once the regression equations have been determined for log value, $\hat{Y}_{2jk}$, and log volume $\hat{Y}_{1jk}$, log value and log volume are estimated for selected diameters. Average value per 1,000 board feet of logs (M_{jk}) is calculated for each diameter selected.

$$M_{jk} = \frac{\hat{Y}_{2jk}}{\hat{Y}_{1jk}}$$

OPERATING OPTIONS

Flow charts I and II illustrate the options available in operation of the two programs together or separately.

I. Combined Programs--If a new mill study has been made and tables of Y_{1jk}, Y_{2jk} and M_{jk} are desired, the program would begin with Flow Chart IA and continue with Flow Chart IIA and IIB, omitting IB.

   A. Calculating Individual Log Values and Log Volumes. Flow Chart IA.

      1. Data Input Cards. The data input card format to be used is shown in Appendix A. This card format is different from the Basic Data Card #3 ordinarily used for the Newport-Leach program. The modification is made at this point to avoid modifying subsequent cards.

      2. Output Cards. The output is a modified Deck 6 whose format is shown in Appendix B.

   B. Calculating Regression of Log Volume of Log Diameter. Flow Chart IIA.

      1. Data Input Cards. To compute the volume-diameter regression and tables, it is necessary to prepare a "surfaced-dry volume"

Mill Study Data

Rough-dry lumber grade recovery from each log of known diameter and log grade and total rough-dry lumber vol. of log

Conversion Factors
Rough-dry lumber grade volume to surfaced dry lumber grade volume

Rough-green lumber grade recovery from each log of known diameter and log grade and total rough-green lumber vol. of log

Conversion Factors
Rough-green lumber grade volume to surfaced dry lumber grade volume

Compute
Surface dry lumber grade volume and total surface dry volume for individual logs

Surface-dry lumber grade recovery from each log of known diameter and log grade and total surface dry volume of log

Lumber Prices
Lumber price for each lumber grade

Value of each log of known diameter and log grade

NEWPORT - LEACH PROGRAM

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Value of each log of known diameter and log grade

Surfaced-dry volume of each log of known diameter and log grade

Compute

$$Y_{1jk} = a_{1jk} + b_{1jk} X + c_{1jk} X^2$$
$$Y_{2jk} = a_{2jk} + b_{2jk} X + c_{2jk} X^2$$

Solve $\hat{Y}_{1jk}$ & $\hat{Y}_{2jk}$ for given values of X and prepare tables of volume and value given log diameter

Compute

For each given X

$$\frac{\hat{Y}_{2jk}}{\hat{Y}_{1jk}} = M_{jk} = \frac{value/1000}{ft.\ b.m.}$$

Prepare tables of M_{jk} for given X's

Normal equations for each regression

$$\hat{Y}_{ijk} = a_{ijk} + b_{ijk} X + c_{ijk} X^2$$

FRAZIER - CARNEY
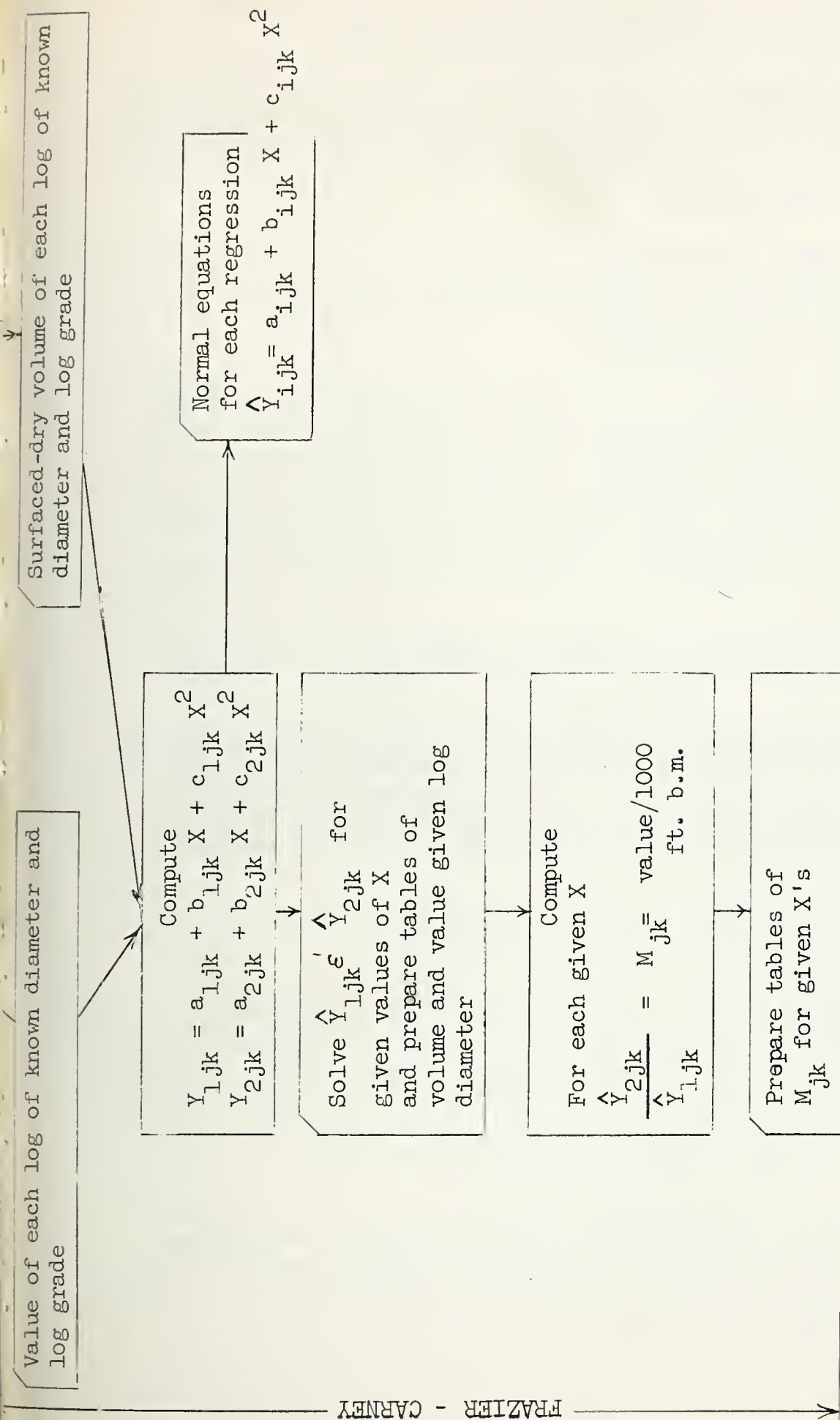
Figure 1.--Schematic presentation of program and its integration with Newport-Leach Program.

deck as shown in Appendix C. This deck can be prepared
directly from the output deck from A.2 above.

2. Input Control Card. "Diameter Limit Load" Deck. This deck
determines what diameters will be used in solving the regres-
sion equation. There must be one card for each regression of
the data as indicated by cols. 9 and 10. The card format is
shown in Appendix D.

3. Output Cards. The output is composed of J times K decks of
cards. The first 3 cards of each deck contain the normal
equations of volume regressed on diameter. Their format is
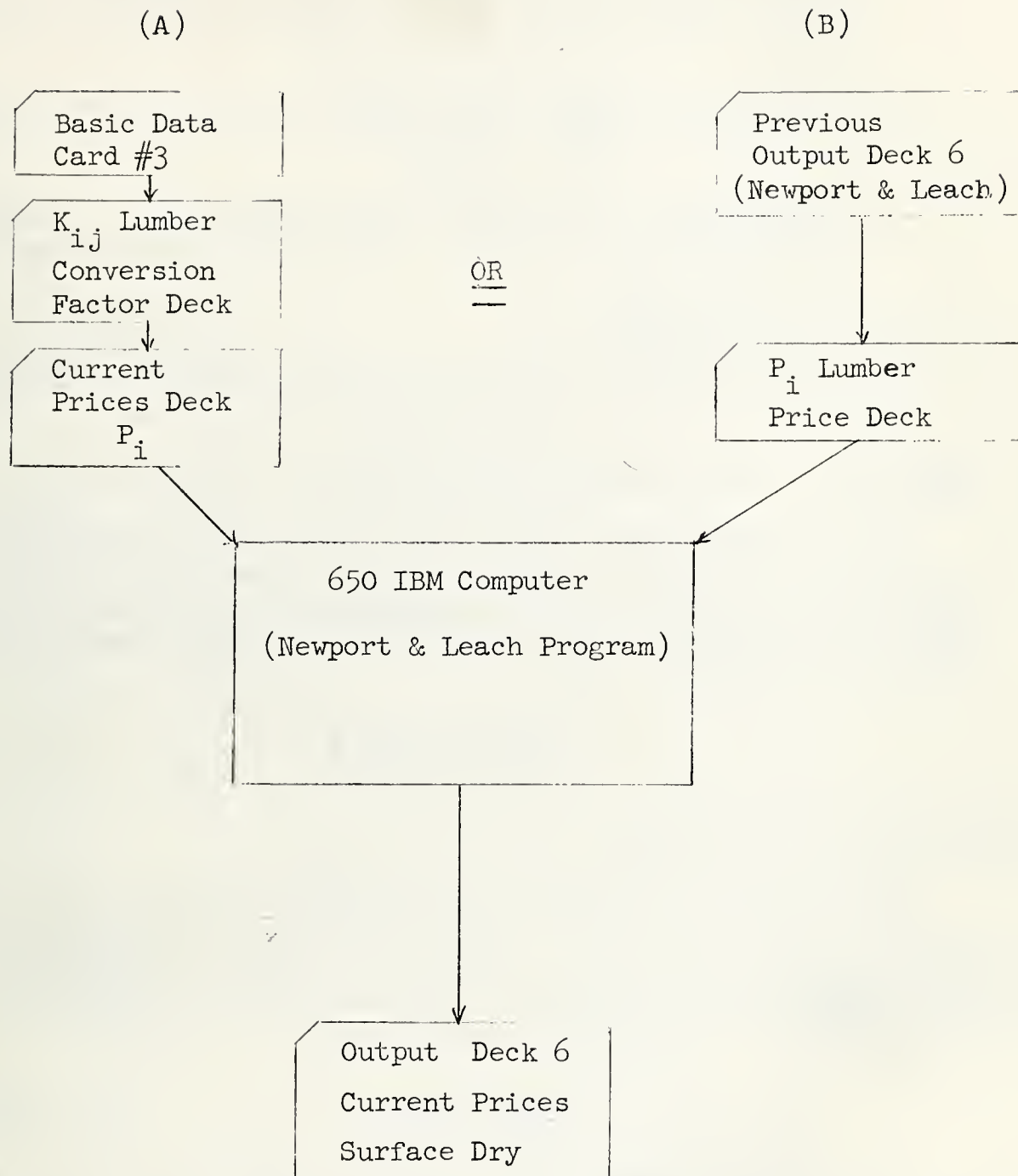illustrated in Appendix E.

Following each set of normal equations will be a deck
of cards whose format is shown in Appendix F. Each card
contains the volume computed from the regression for each
of the diameters between the minimum diameter and the
maximum diameter. Note that a sign switch setting is pro-
vided in the program to prepare either unit inch cards
("4" punch in column 1) or one-half inch cards ("5" punch
in column 1).

C. Calculating Regression of Average Log Value per 1,000 bd. ft.
Flow Chart IIB.

1. Data Input Cards. The output from I.A.2 becomes a part of
the input for this section of the program in combination with
the "volume-diameter" decks which are output from I.B.3.
It is absolutely necessary that these two separate sets of
data decks are ordered on columns 9 and 10 in the same
sequence.

2. Input Control Cards. "Diameter Limit Load" Deck. This must
be the same deck of cards used in I.B.2.

3. Output Cards. The output is composed of J times K sets of cards.
Each set is composed of three decks. The first deck comprising
three cards is the normal equations of the log value-diameter
regressions. The second deck is the value-diameter table for
the diameters specified. The final deck is the value per 1,000
bd. ft.-diameter table for these same diameters.

II. Option II: computing new appraisal values as a result of lumber-
grade price changes. The program provides a bypass to eliminate
those parts which are not affected by price changes. This option
begins with Flow Chart IB and continues through Flow Chart II, elimina-
ting Flow Chart IIA.

FLOW CHART I

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(A)   (B)

Basic Data
Card #3

K_{ij} Lumber
Conversion
Factor Deck

OR

Previous
Output Deck 6
(Newport & Leach)

Current
Prices Deck
P_i

P_i Lumber
Price Deck

650 IBM Computer

(Newport & Leach Program)

Output Deck 6
Current Prices
Surface Dry

A. Flow Chart IB.

    1. Data Input Cards. If the card format shown in the Newport-Leach program for Deck 6 has been the previous output from Flow Chart IA or IB, then this card should be modified to conform to the card format as shown in Appendix B. If Flow Chart IA or IB has been run with cards previously modified so the output has the format shown in Appendix B, then no further modification is necessary.

    2. Input Control Card. The "Diameter Limit Load" deck will be required as in Option I.

    3. Output Cards. The output is the same as that from Option I with new log values as a result of the new prices.

B. Flow Chart IIA--Omitted.

C. Flow Chart IIB. The input, control, and output are the same as those of the combined programs Option I, part C.

III. Option III: computing new volume--diameter tables.

If the operator has secured new volume-diameter data and desires to use these to compute values, then Flow Chart IIA can be used separately from the rest of the program to compute new normal equations and regressions. The procedure would be the same as that indicated in Option I, part B.

<center>CONTROL CARDS</center>

Diameter Limit Load Deck (D_i).

For optimum efficiency of the program, a diameter limit load card has been included to control the minimum and maximum diameters used in both the value and volume regressions. These limits may vary between log grade system and log grade. One diameter limit card must be prepared for each log grade subset of the data (see Appendix D).

<center>RESTRICTIONS</center>

1. Control Columns. The program is restricted to 36 combinations of study, species, log-grade system, and log grade. This restriction is controlled by columns 9 and 10 in the input cards. Column 9 must be used as a primary control and column 10 as the secondary control.

In processing data for Region 5, the following coding in column 9 and 10 was used.

FLOW CHART II

```
        ┌─────────────────────┐
        │ Output   Deck 6     │
        │ Newport & Leach     │
        │ Program             │
        └──────────┬──────────┘
                   │
                   ▼
           ╱ ─ ─ ─ ─ ─ ─ ╲
          (  Modification  )
          (   of Card      )
           ╲   Format    ╱
            ╲ ─ ─┬─ ─ ╱
 (A)              │              (B)
  ┌──────────────┴──────────────┐
  │                             │
  ▼                             ▼
┌───────────────────┐     ┌───────────────────┐
│ Volume-Diameter   │     │ Value-Diameter    │
│ Input Card        │     │ Input Card        │
└─────────┬─────────┘     └─────────┬─────────┘
          │                         │
          │   ┌──────────────────┐  │
          │   │ Program Deck     │  │
          └──▶│ (Frazier-Carney) │◀─┘
              │ & Control Cards  │
              └────┬────────┬────┘
                   │        │
                   ▼        ▼
        ┌────────────────────────────┐
        │                            │
        │                            │
        │     IBM 650 Computer       │
        │                            │
        │                            │
        └──────┬──────────────┬──────┘
               │              │
               ▼              ▼
```

```
┌──────────────────┐
│ Volume-Dia-      │
│ meter Tables     │◀───
└──────────────────┘
┌──────────────────┐
│ Normal           │
│ Equations        │
│ Volume-Diameter  │
└──────────────────┘

              ┌──────────────────┐
              │ Value /M         │
              │ Tables           │
              └──────────────────┘
              ┌──────────────────┐
              │ Value-Diameter   │
              │ Tables           │
              └──────────────────┘
              ┌──────────────────┐
              │ Normal           │
              │ Equations        │
              │ Value-Diameter   │
              └──────────────────┘
```
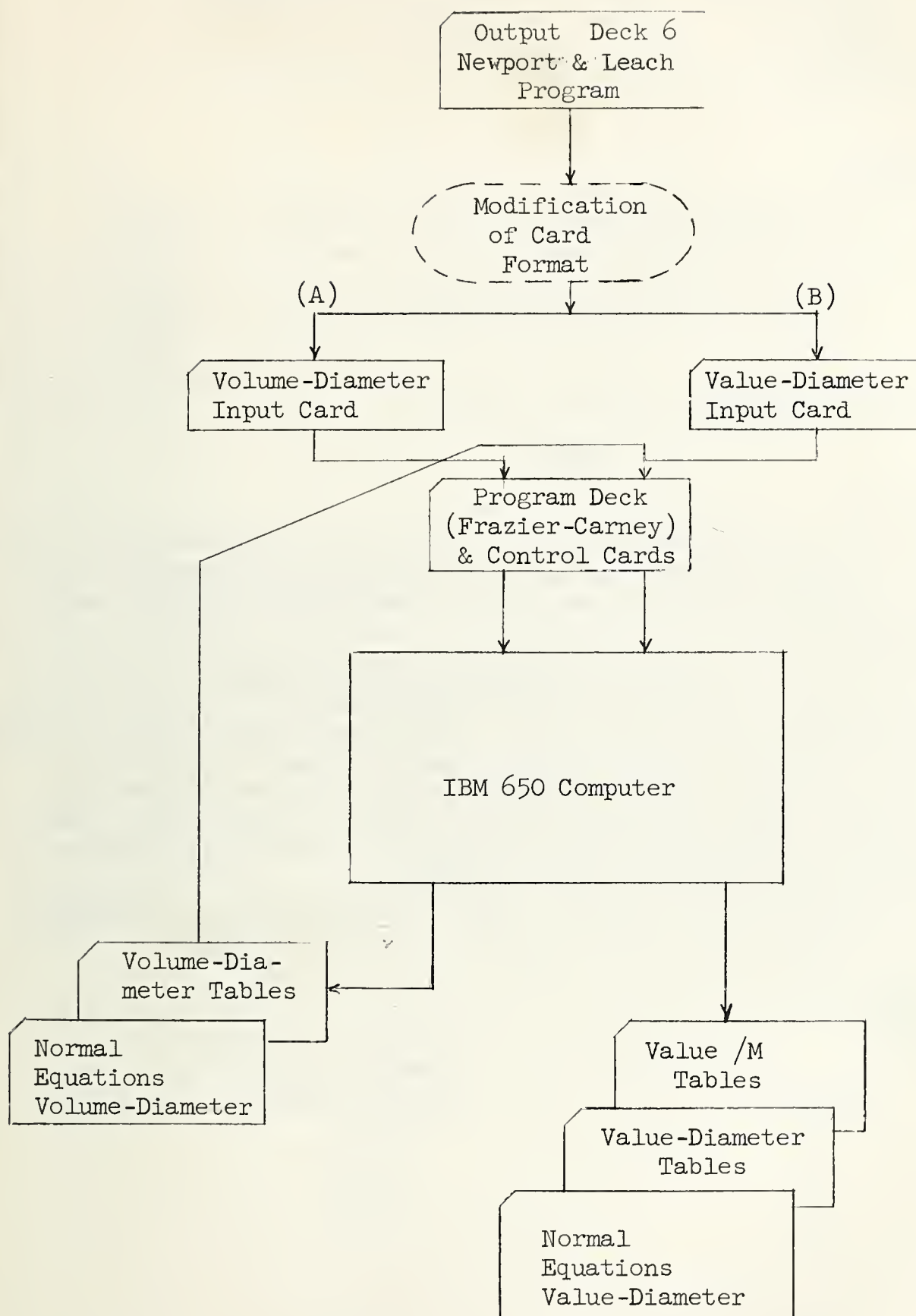
Column 9

1 = Ponderosa pine - California Westside Log Grade System
2 = Ponderosa pine - Region 6 (PNW) Log Grade System
3 = Sugar pine - California Westside Log Grade System
4 = Not used
5 = Not used
6 = Not used

Column 10

1 = Log grade, given system and species defined by Column 9
2 = Log grade, given system and species defined by Column 9
3 = Log grade, given system and species defined by Column 9
4 = Log grade, given system and species defined by Column 9
5 = Log grade, given system and species defined by Column 9
6 = Log grade, given system and species defined by Column 9

2. Scaling Data. Individual input datum must be scaled to con-
form to the field limitations of each input card.

OUTPUT

Normal Equations

The output from Flow Chart IIA contains the coefficients "a," "b,"
and "c" and the sums of the squares and cross products (see Output Card 2,
Appendix E). One set of three normal equation cards is punched for each
regression computed.

Log Volume, Log Value, and Value per 1,000 board feet Tables

The program provides tables for volume, value, and value per 1,000
board feet as punch card output for 1-inch diameter classes on unit inch
points (4 punch, column 1) and on half-inch points (5 punch, column 1).
The half-inch point table permits the program user to select those volume
or value cards which are diameter class mid-points for any size diameter
class as limited by the diameter limit load deck.

For example, if the unit inch switch is selected, the unit inch
diameter output cards (4 punch in column 1) will be as follows:

If Dmin = 9"

Diameter	Volume, value, or value per 1,000 board feet
09	xxxxxx
10	xxxxxx
11	xxxxxx
12	xxxxxx
.	.
.	.
.	.
Dmax	xxxxxx

The half-inch point table output cards (5 punch in column 1) will be as follows:

Diameter punch in Columns 7, 8 Output Card	Actual diameter	Volume, value, or value per 1,000 board feet
09	9.5	xxxxxx
10	10.5	xxxxxx
11	11.5	xxxxxx
.	.	.
.	.	.
.	.	.
Dmax	Dmax + 1/2"	xxxxxx

OPERATING INSTRUCTIONS

This program has been prepared for the IBM 650 and the Remington-Rand Univac Solid State 80 computers. Program cards and operating instructions for either machine can be obtained by writing to the Director, Pacific Southwest Forest and Range Experiment Station, P. O. Box 245, Berkeley 1, California.

OPERATING TIME

The Newport-Leach 650 program is estimated to operate at the rate of 330 cards per hour. However, when value only is computed the rate is increased to 1,440 cards per hour. These estimates should be used for Flow Chart I when estimating operating time for the combined program.

The estimated operating rate of The Frazier-Carney Program is 2,400 cards per hour. This rate is based upon the card count of the input data. However, when tables are being computed over a large range of diameters and the number of data input cards is relatively small, the program options may operate at a slower rate.

APPENDIX

A. Sample 650 Input Card, Basic Data Card No. 3 (Modified) (X_i)

Column	Field
1	Card Number (code 3)
2-3	Study Number
4-6	Log Number
7-8	Log Diameter
9	Species-system
10	Log Grade
11-23	Other Log Identification as desired
24-27	X_1 Rough Volume of B and Better (board foot, 1 decimal)
28-31	X_2 Rough Volume of C Select (board foot, 1 decimal)
32-35	X_3 Rough Volume of D Select (board foot, 1 decimal)
36-39	X_4 Rough Volume of Misc. Select (board foot, 1 decimal)
40-43	X_5 Rough Volume of No. 3 Clear (board foot, 1 decimal)
44-47	X_6 Rough Volume of No. 1 Shop (board foot, 1 decimal)
48-51	X_7 Rough Volume of No. 2 Shop (board foot, 1 decimal)
52-55	X_8 Rough Volume of No. 3 Shop (board foot, 1 decimal)
56-59	X_9 Rough Volume of 1 and 2 Common (board foot, 1 decimal)
60-63	X_{10} Rough Volume of 3 Common (board foot, 1 decimal)
64-67	X_{11} Rough Volume of 4 Common (board foot, 1 decimal)
68-71	X_{12} Rough Volume of 5 Common (board foot, 1 decimal)
72-75	X_{13} Zero
76-79	X_{14} Zero
80	Zero

B. Sample 650 Output Card, Surface Dry Volume and Value Card No. 6

   (Y_i) (Modified)

Column	Field
1	Card Number (code 6)
2,3	Study Number
4-6	Log Number
7,8	Log Diameter
9	Species-system
10	Log Grade
11	Zero
12-16	Total Volume of Log, Surface Dry Lumber (board foot, 1 decimal)
17-23	Value of Log, Surface Dry Lumber in Dollars (2 decimals)
24-27	Y_1 Surface Dry Volume of B and Better (board foot, 1 decimal)
28-31	Y_2 Surface Dry Volume of C Select (board foot, 1 decimal)
32-35	Y_3 Surface Dry Volume of D Select (board foot, 1 decimal)
36-39	Y_4 Surface Dry Volume of Misc. Select (board foot, 1 decimal)
40-43	Y_5 Surface Dry Volume of No. 3 Clear (board foot, 1 decimal)
44-47	Y_6 Surface Dry Volume of No. 1 Shop (board foot, 1 decimal)
48-51	Y_7 Surface Dry Volume of No. 2 Shop (board foot, 1 decimal)
52-55	Y_8 Surface Dry Volume of No. 3 Shop (board foot, 1 decimal)
56-59	Y_9 Surface Dry Volume of 1 and 2 Common (board foot, 1 decimal)
60-63	Y_{10} Surface Dry Volume of 3 Common (board foot, 1 decimal)
64-67	Y_{11} Surface Dry Volume of 4 Common (board foot, 1 decimal)
68-71	Y_{12} Surface Dry Volume of 5 Common (board foot, 1 decimal)
72-75	Y_{13} Zero
76-79	Y_{14} Zero
80	Zero

C. Sample 650 Input Card, Surface Dry Volume Card No. 6

Column	Field
1	Card Number (code 6)
2,3	Study Number
4-6	Log Number
7,8	Log Diameter
9	Species-system
10	Log Grade
11	Zero
12-16	Zeros
17-23	Log Volume, Surface Dry (two decimals)
24-80	Zeros

(Note: High (Y) punches in all low order positions)

D. Diameter Limit Load Deck (D_i) Type 3

Column	Field
1	Card Number (code 3) Y punch)
2,3	Study Number
4-8	Zeros
9	Species-system
10	Log Grade
11-20	Minimum Diameter (no decimals)
21-30	Maximum Diameter (no decimals)
31-80	Zeros

(Note: High (Y) punches in all low order positions)

E. Output Card 2 - Regression Equations - One Set of 3 Cards Per
    Regression Equation Computed

Column	Card No. 1	Card No. 2	Card No. 3
1	.... Card Code 2		
2,3	.... Study Number		
4	Card Number 1	2	3
5-8	.... Zeros		
9	.... Species-system		
10	.... Log Grade		
11-20	ΣY	ΣXY	$\Sigma X^2 Y$
21-30	N	ΣX	ΣX^2
31-40	"a"	"a"	"a"
41-50	ΣX	ΣX^2	ΣX^3
51-60	"b"	"b"	"b"
61-70	ΣX^2	ΣX^3	ΣX^4
71-80	"c"	"c"	"c"

F. Output Card - Solution of Regressions of Volume or Value Given
   Diameter - Type 4 or Type 5

Column	Field
1	Card Code (4 or 5)*
2,3	Study Number
4-6	Card Number (punched in sequence)
7,8	Diameter**
9	Species-system
10	Low Grade
11-12	Volume or Value ($\hat{Y}_i$) (2 decimals)
21-80	Zeros

G. Output Card - $\overline{M}$ - Table Type 7 Card

Column	Field
1	Card Code (7)
2,3	Study Number
4-6	Card Number (punched in sequence)
7,8	Diameter **
9	Species-system
10	Log Grade
11-20	$\overline{M}$ - Y_2/Y_1
21-30	$\hat{Y}_2$ = Value
31-40	$\hat{Y}_1$ = Volume
41-80	Zeros

* Note: An output card with a "4" punch in column 1 indicates a unit
inch point output card. A "5" punch in column 1 indicates a 1/2 inch
point output card.
** Note: Diameters will always be entered as integers. Consequently
in the Type 5 cards the actual diameter used in the calculation of $\hat{Y}$ will
be 1/2" larger than that punched in columns 7, 8 of the card.